Core Body Temperature and its Effect on Breath Alcohol Measurement

By Phillip B. Price Sr.
And
George D. Flowers

Temperature measurement has a dramatic effect on breath alcohol analysis. All breath alcohol testing devices on the market today make certain assumptions relating to temperature. The primary variables associated with temperature as it relates to breath alcohol testing are the core body temperature of the person being tested, and the temperature of the breath. The very foundation of breath alcohol testing, Henry's Law of Gases, assumes a constant temperature in order for the result to be considered valid. If temperatures exist other than those assumed to be constant, the obvious result is an erroneous breath test value reported. In today's criminal justice system, with more serious penalties employed if convicted of an alcohol related offense, along with the reduction of the so-called "legal limit," the issue of temperature will become more and more closely scrutinized.

It is the purpose of this paper to discuss the effect of the temperature of the breath itself, as well as the effect of the core body temperature and their effect on the test result reported by the device. State prosecutors and state's witnesses do not like to talk about the issue of temperature and its effect on breath testing. The vast majority of data indicates that with all of the breath test devices currently being used, a person being subjected to a breath test is far more likely to be negatively effected by temperature variations, than benefited. Despite the fact that the effect of temperature on breath alcohol measurement has been generally accepted by the scientific community, numerous "scientists" employed by the various states still insist that the effect of temperature on breath testing is either nonexistent or so small that it is not a serious factor of potential error. These same "scientists" will justify their claim that taking temperature into consideration in a breath alcohol measurement is unnecessary. They argue that other systems are in place within their breath testing program so that they have negated the effect that any variance in temperature might have on the subject test.

The primary claims that the government's "expert" witness will make to justify their refusal to address the temperature issue will be to claim (1) the 1 to 2100 breath to blood ratio is in favor of the subject, (2) the benefit of taking two samples and using the lower of the two, or (3) normal breath temperature will vary so moderately from 34 degrees that the effect is irrelevant. However, in reality these arguments used in defending a breath testing program are no more effective in this issue than was the Maginot Line in defending France. While these arguments by a State's breath testing program may appear impressive on their face, they do come close to addressing the issues of not only breath temperature but also of core body temperature as well. As you will see, both have a substantial effect on an analysis of breath alcohol measurement.

One of the most arguable aspects of any breath alcohol testing program is the presumption of a fixed blood-to-breath ratio. Every breath alcohol testing device uses a presumed blood-to-breath ratio of one molecule of alcohol per cc of volume of breath to twenty one hundred molecules in that same one cc volume of blood. The assumption is made that all individuals possess this same ratio and that it remains constant at all times in that individual. Neither assumption is true. This ratio occurs in the area of the deep air sacs of the lungs where a portion of the consumed alcohol is being eliminated from the body. It goes without saying that in general, when a person consumes alcohol that alcohol must reach the brain of the subject before he undergoes any potentially impairing effects. Even before an individual becomes fully post-absorbtive, the alcohol in his system begins to be eliminated from the body in numerous ways. One of the methods which alcohol leaves the body is through expiration in breath. The rate at which the alcohol is eliminated in the human breath can be dependent upon numerous factors. One of the most common factors effecting breath alcohol expiration is the core body temperature of the subject being tested. The higher the temperature, the more alcohol is being eliminated from the body.

The effect of temperature on breath alcohol analysis is beginning to be recognized by some manufacturers of breath testing devices. Instruments designed by Draeger have an option which is intended to allow the instrument to measure the temperature of exhaled breath as it enters the breath tube. This breath temperature monitoring technology can be integrated into the software of the instrument in order to give the device the ability to make a correction for the temperature of the breath. Dreager has recognized the potential negative effect of temperature on breath alcohol analysis, however, this may not adequately address the proper issue.

This breath temperature correction, as it has commonly been referred to, is in fact a somewhat misleading concern. It is not the temperature of the breath that needs to be accounted for and corrected, but it is in fact the core body temperature as reflected by breath temperature of the subject being tested. It is the core body temperature of a subject that can potentially cause a false elevation of breath alcohol levels. The temperature of the breath has been focused upon because the core body temperature of the subject being tested has been presumed to correlate with the breath temperature of that subject.

The equilibrium distribution of ethyl alcohol between air and blood is described by Henry's Law of Gases. This equilibrium distribution is called the partition constant, or partition coefficient, and is the ratio of the weight of alcohol per unit of volume of air to the weight of alcohol per unit volume of blood. The partition constant varies with temperature, so that at high temperatures, air takes up more alcohol from a standard solution in blood than at low temperatures. Thus, differences in breath temperature, which are indicative of differences in core body temperatures, could result in variations in the analysis of a subject's breath for the purpose of examining the alcohol content therein.

A simple illustration of this phenomenon would be to imagine a pot of boiling water on a stovetop. In this example, we are trying to determine the amount of water in the pot, which is unknown, by using two known values. Here, our first known value is the temperature of the stovetop, which is set on 340 degrees. Secondly, (through the use of Beer's Law and the Lambert-Bouger Law) we are able to calculate the amount of steam coming off the pot by flashing a beam of a known quantity of light through the steam and calculating how much light was absorbed by the steam. By measuring the amount of steam at a fixed instant coming off the boiling water in the pot, we now have two of three variables determined, and thus, are able to calculate the third variable. In the above example, the stovetop is analogous to the subject's body temperature and the steam is analogous to the expirational breath alcohol of the subject. Unfortunately, as is often the case when dealing with human beings, the variables to be considered in this determination are not as static as the example above.

For instance, what if in the above example the stovetop temperature were unknowingly set at 350 degrees? The effect would be more steam produced per second from the same quantity of water. Thus, by plugging in this new reading of the amount of steam being produced per second into our calculation, we would mistakenly determine that the volume of water contained within the pot was greater than that which was actually there.

Most every breath testing device in the United States assumes that every individual tested has a breath temperature of 34 degrees centigrade. A breath testing device measuring a person whose body temperature is above 34 degrees centigrade, would produce a falsely elevated result and report the subject as having a blood alcohol concentration greater than that actually present. All breath testing devices used for evidentiary purposes in this country start with the proverbial presumption that all the stoves are set to "340 degrees," i.e. that all body temperatures are such that the expired breath of the subject will be at 34 degrees centigrade. This, however, is clearly not the case.

In 1987, Dr. Glyn R. Fox and Dr. John S. Hayward published a paper entitled "Effect of Hypothermia on Breath-Alcohol Analysis," Journal of Forensic Sciences, JFSCA, Vol. 32, No. 2, March 1987, pp. 320-325. As part of their analysis, Doctors Fox and Hayward dosed subjects with "an experimental drink consisting of 95% (v/v) ethanol: distilled water, dose 1.15-mL 95% ethanol ... mixed with unsweetened orange juice of a volume equal to three times that of the dose of ethanol." Id at 322. (i.e.

screwdrivers). Once the subjects had fully absorbed the alcohol and entered a post-absorbtive state the subjects had thermistors inserted to measure their core body temperature. They were then immersed up to the neck in water chilled to 10 degrees centigrade so as to induce mild hypothermia. During this process the subjects were given several breath alcohol tests. The results of the study showed that there was a 7.3% difference of the breath alcohol reading off the normal alcohol curve for every one degree that the body temperature changed. In their study they were able to easily produce a variance of 22 percent. Furthermore, Dr. Fox and Hayward recognized that this principle "should apply equally well to the case of hyperthermia, where such error would increase the subject's likelihood of being unjustly convicted." Id. at 323.

Several studies in relatively recent times have reevaluated the misconception that expired breath temperature is in fact 34 degrees centigrade. One of the more recent studies on breath temperature was conducted on subjects who had been arrested for DUI within the State of Alabama. Carpenter, D.A., and Buttram, J.M., "Breath Temperature: An Alabama Perspective," International Association for Chemical Testing Newsletter, Vol. 9, No. 2, July 1998, pp. 16-17. These subjects after being arrested for DUI were given evidentiary breath tests and the temperature of their breath was recorded. It was found that approximately 87% of the subjects arrested had a breath temperature above 34 degrees centigrade and that the mean breath temperature of the individuals was 34.9 degrees centigrade. "This is in agreement with the earlier work of Harger and Forney, Schoknecht and Stock who found mean breath temperatures of 35.1 degrees and 35 degrees C, respectively." Id at 16.

To phrase this information another way, approximately 87% of individuals who are arrested for DUI and subsequently offered an evidentiary breath could have had a false elevation of their reported blood alcohol level because of elevated core body / breath temperature. It should be specifically noted that if we are to assume a mean breath temperature of 35 degrees or greater, one degree or more above the accepted 34 degrees, that approximately the individuals being subjected to breath tests may be having their blood alcohol level overestimated by at least 7 percent based on simple core body temperature alone.

These findings are consistent with this firm's analysis of different breath samples performed over a several month period in cases where breath tests were performed for evidential purposes on an instrument measuring breath temperature. The data in this analysis reported breath temperatures ranging from 33.8 to 35.8 degrees, with an average temperature of 35 degrees centigrade. Furthermore, 52.5% of the subjects tested had a breath temperature of 35 degrees or more. The taking of two breath samples and using only the lower of the two for evidentiary purposes had only a very minor effect of the impact of elevated breath temperature. After duplicate testing and then examining only the lower of the two tests, **90% of the subjects tested still had a breath temperature above 34 degrees.** All instruments used in these studies were calibrated to take the initial measurements of the breath alcohol content using the standard 1 to 2100 blood to breath ratio. Thus, it is apparent that the claims regarding the ability of duplicate sampling and the 1 to 2100 blood to breath ratio to compensate for potential variances in core body temperature seem to be greatly over-exaggerated.

Another recent contribution to the analysis the effect of breath temperature on breath alcohol measurement looked at several other factors which could result in either a falsely high or low breath temperature measurement. One of the numerous factors which could have a potential cooling effect on breath temperature, which in turn would indicate a falsely low core body temperature, is the mouthpiece used in the device. Bell, C.M. and Flack, H.J., "Examining Variables Associated with Sampling for Breath Alcohol Analysis," Victoria Forensic Science Center. The theory behind this phenomenon is that the mouthpiece will invariably be at a lower temperature than a subject's breath, and thus, the mouthpiece could have a cooling effect on the breath as it passes through. Bell and Flack found that breath temperatures were lowered by approximately one degree centigrade when a mouthpiece was used. Thus, it is certainly possible that mean breath temperatures may in fact be slightly higher than those previously thought. If mean breath temperatures are in fact in the range of 36 degrees, two degrees over the accepted 34 degrees centigrade, then approximately 50% of the persons tested for evidentiary purposes could potentially need to have their reported blood alcohol tests results reduced by approximately 14% based solely upon elevated core body temperature.

The purpose of measuring breath temperature of a subject is to take an unobtrusive measurement of the core body temperature of that subject. What we think of as normal body temperature is an equilibrium core temperature which is reached in conditions of thermal inactivity. However, it is not uncommon at all for individuals engaging in aerobic exercise or those suffering from a fever to achieve body temperatures in excess of 38 degrees (100 degrees Fahrenheit). Individuals such as these, based solely upon core temperature, have tremendous potential to have a falsely elevated breath alcohol reading of 20% or more.

For the greater part of the twentieth century, technology has been in place which allows temperature measurement of a dynamic gas. Moreover, numerous authors have not only encouraged the use of breath temperature measurement but have also given cost effective means for measuring either breath or body temperature. When one considers the devastating effects, in a criminal case were breath alcohol is being used to prove a blood alcohol level, to individuals whose core body temperature may be elevated beyond 34 degrees centigrade it is unfathomable why jurisdictions refuse to address this issue.

© 2002, Phillip B. Price and George D. Flowers

TEMPERATURE CONVERSION

Fahrenheit (°F)

This is probably the most familiar temperature scale. On this scale, there are 180 degrees between the freezing and boiling points of water. Water freezes at 32 degrees Fahrenheit and it boils at 212 degrees Fahrenheit. See Figure 2.

Centigrade (°C)

Scientific measurements of temperature are generally made by using the Centigrade scale. This may also be referred to as the Celsius scale. Water freezes at 0 degrees Centigrade and it boils at 100 degrees Centigrade. Since there are 100 degrees between the freezing and the boiling points of water on this scale, one can see that each degree Centigrade is 1.8 times as large as each degree Fahrenheit. See Figure 2.

Temperature Conversion Formulas

1. $°F = (9/5 \times °C) + 32$ OR $°F = (1.8 \times °C) + 32$

2. $°C = 5/9\ (°F - 32)$ OR $°C = (°F - 32) \div 1.8$

Example: Convert 50°C to degrees Fahrenheit.

$$°F = (9/5 \times °C) + 32$$
$$°F = (9/5 \times 50) + 32$$
$$°F = 90 + 32$$
$$°F = 122.0$$

Example: Convert 98.6°F to degrees Centigrade.

$$°C = 5/9\ (°F - 32)$$
$$°C = 5/9\ (98.6 - 32)$$
$$°C = 5/9\ (66.6)$$
$$°C = 37.0$$

Fahrenheit °F		Centigrade °C
212	Water Boils	100
98.6	Body Temperature	37
93.2	Breath leaves mouth	34
70.0	Room Temperature	21.1
32.0	Water Freezes	0
0		-17.7
-459.4	Absolute Zero	-273

To Convert:

$$°C = 5/9\,(°F - 32) \qquad °F = (9/5 \times °C) + 32$$

Figure 2. The relationships among temperature scales.

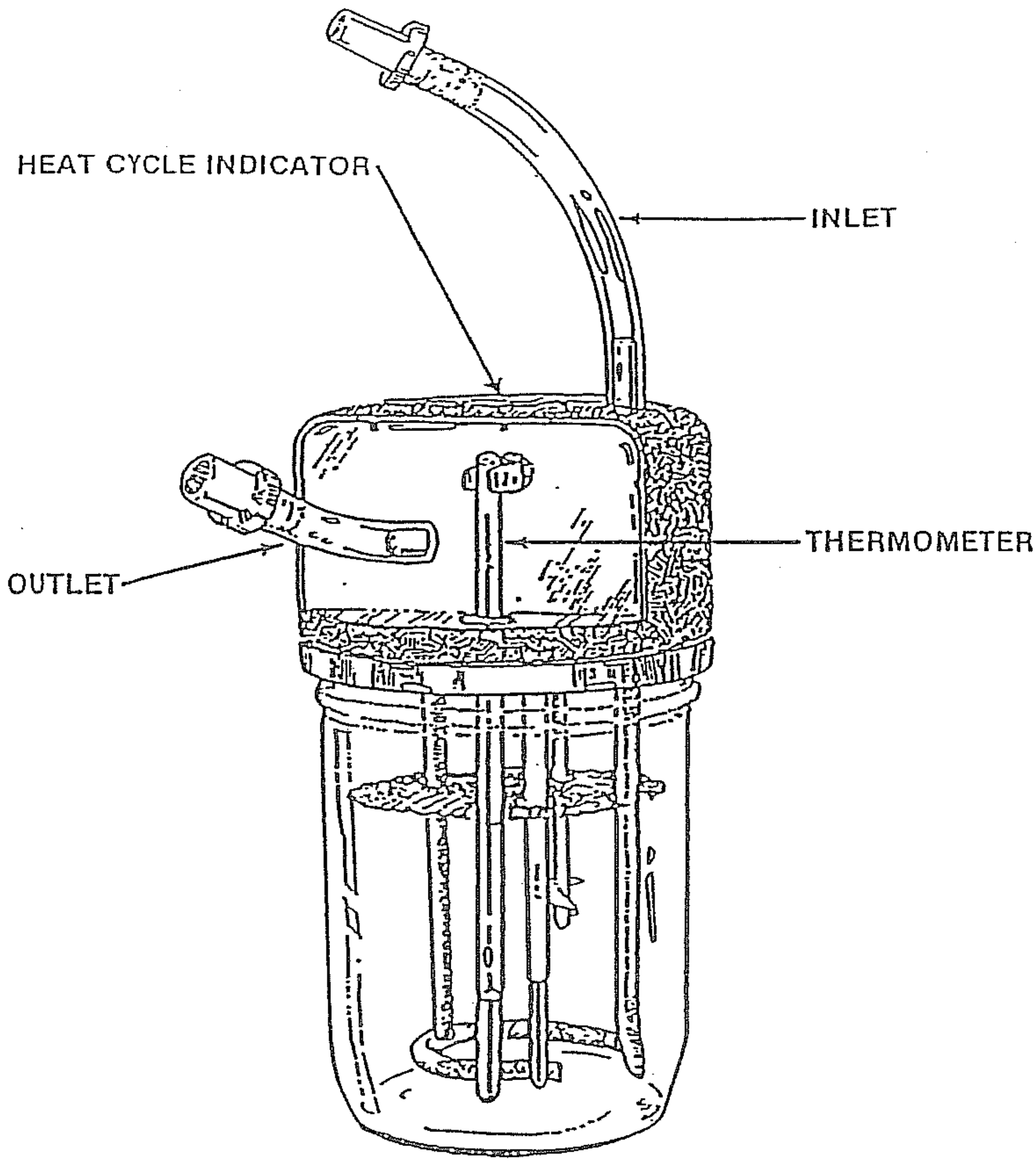
SIMULATOR

The reference device is a piece of allied equipment that can be used to verify the accuracy and precision of an Intoxilyzer 5000.

This device is designed to deliver a sample of vapor containing a known or predicted amount of ethyl alcohol. It simulates the breath sample of a person with a known alcohol concentration. The reference device is commonly referred to as a "simulator". Since it is simulating human breath, the reference device is designed to operate at 34 + or - 0.2°C (33.8 to 34.2°C), approximately 93.2°F.

The theory of operation of any reference device is based upon Henry's Law. According to Henry's Law, at a given temperature, the amount of alcohol in the air (reference sample) is proportional to the amount of alcohol in the water (reference solution). The relationship between how much alcohol is in the reference solution versus how much is in the reference sample is called the partition ratio. The partition ratio changes as the temperature of the solution changes. If the solution temperature is low, the reference results will be low. If the solution temperature is high, the reference results will be high.

The reference solution is prepared by a qualified person. The reference solution should be changed as directed by the current rules and regulations.



MODEL MARK IIA SIMULATOR